AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

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CCXVI.

(Vol. X.—February, 1881.)

THE SEWERAGE OF MEMPHIS.

By FREDERICK S. ODELL, C. E.

READ AT THE ANNUAL MEETING, NOVEMBER 3, 1880.

WITH DISCUSSIONS

By EDWARD S. PHILBRICK, J. J. R. CROES, GEORGE W. DRESSER, ROBERT CARTWRIGHT, SAMUEL L. SMEDLEY, WILLIAM E. WORTHEN, ASHBEL WELCH, JOHN BOGART and GEORGE E. WARING, Jr.

After nearly half a century of indifference to that virtue which ranks next to Godliness, and almost utter disregard of the simplest sanitary laws, it became apparent, after the deplorable epidemics of 1878 and '9, that some radical reformation must be accomplished in the sanitary con-

dition of Memphis; acting on this conviction, and the recommendation of the National Board of Health, her representative men determined upon the accomplishment of a sanitary revolution for their town.

At that time little had been done, practically, in the way of sewerage, and that little was done by private enterprise; there were no public sewers, and the refuse and filth were delivered into cesspools and private vaults, while not a small portion found its way into the gutters of the public streets, and these during a prolonged dry season became reeking and putrescent, and emitted the foulest odors. Nor was this all. Some years ago, many of the streets were paved with Nicholson pavement, and these had very much decayed, and readily absorbed much of the liquid filth that flowed over the rotten gutters, and in course of time became so permeated with it that the periodical flushings of rain storms utterly failed to cleanse them, and they were the constant source of poisonous exhalations. This, added to the emanations of privy vaults in the rear of dwellings, and sometimes in the very dwellings themselves, in the cellars, and within contaminating distances of wells and cisterns, created an atmosphere that was doubtless among the prolific causes of the spread of contagion.

The facts here cited were sufficiently apparent to make the better disposal of sewerage a matter of imperative necessity, but the outlook for it was not a cheerful one, for at the outset, the municipal commission was confronted by plans and estimates of cost ranging from one million five hundred thousand to three million dollars and upward. This amount, in the condition of Memphis, bankrupt by reason of official mismanagement and plunder, with the additional disadvantage of two successive seasons of distressing epidemic, resulting in the paralization of her industries and the discouragement of her tradesmen, made the possibility of raising this large amount very problematical, if not totally impossible.

During the discussions that ensued pending the approval and adoption of some practical plan for the sewerage of Memphis, the commission sought the council of Mr. Geo. E. Waring, Jr., Sanitary Engineer of Newport, R. I., who boldly advocated the adoption of a system of sewerage hitherto untried on an extensive scale in this country.

This system possesses the distinctive feature of employing the

sewers for the single purpose of conveying sewerage, and rigidly excluding all surface and subsoil drainage; the amount of water necessary to furnish conveyance for such solid matter as enters the sewers, being introduced from another source.

The "Separate System," as this is styled, although not claimed as original, has been adopted by Col. Waring, who is perhaps its most zealous advocate in this country.

The principle, "that two outfalls, independent of each other should be provided; one for the discharge of natural or land and surface waters, and the other for the discharge of artificial or house and soil drainage," and that "a system of impermeable drains should be provided, distinct and separate from the permeable land drains and sewers," "to carry off the house and soil drainage," was announced in 1849, by Mr. Philips, the engineer to the "Metropolitan Commissioners of Sewers," (London).

Although the recommendations based on this principle were not adopted for London, the principle itself contained sufficient merit to commend it to many eminent engineers who have from time to time reasserted the advantages of this system; and the contest then inaugurated has continued to the present day.

Among the many able champions of the "Separate System," might be mentioned John Bourne, C. E., who in a forcible article in 1866, advocated the adoption of two systems of drains, the large to be restricted to rainfall, and the small to house sewerage.*

But the advocates of this system have done more than merely assert its fundamental principles; they have given demonstration of the practicability of their ideas in the construction of sewerage systems in several towns in England. Among others, may be mentioned those of Reading and Oxford, also Halstead; the system in this case being somewhat modified by Mr. Edward Monson, Asso. Inst., C. E. "The sewers being coterminous with the water supply, sluice-valves being placed at the ends of the water mains, and the whole of the system being flushed by the discharge of water for cleansing the mains." The rain fall from the roofs and yards only was allowed to enter the sewers.

So recently as 1876, Mr. Waring desired not to be understood as

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*Engineering, Vol, 2, p. 267,

indorsing all that its advocates claim for what they call the Separate System, and stated "that to keep *all* rainfall out of the sewers, is objectionable for more reasons than one, for no artificial flushing which can be depended on in practice can be so efficient in cleansing the sewers, as the frequent introduction of a sufficient amount of rain water."*

The difficulty here mentioned has been overcome by the application of the automatic flush tank, designed by Mr. Rogers Field, C. E., to the head of each branch sewer, and filling these from the city water supply.

In 1879 Mr. Waring wrote: "This simple device has proved itself, both here and in England, to be entirely reliable and effective. It may safely be assumed that it has secured a reduction of the cost of drainage of small towns to one-half of what was formerly necessary."†

For the application of this system to Memphis, Mr. Waring recommended the construction of small sewers, without man-holes or receiving basins, and the placing of a flush tank of 112 gallons capacity at the head of every branch, the limitation of the size of house drains to four inches, and the exclusion of all rain water.

The estimated cost of this system was only about one-tenth of that of a complete storm water system as ordinarily constructed.

This fact, perhaps, carried greater persuasive force than either the logic or eloquence of Mr. Waring, and after prolonged discussion that developed much bitter opposition, a favorable endorsement of this system was secured, and its adoption urged by the commission. A petition for authority to raise $228,500 was granted by the State Legislature to cover not only the cost of a sewerage system, but also other sanitary work; the laying of about forty miles of subsoil drainage, and also the reclamation of the bayou, by shutting out the high water of the Mississippi by means of a dam with proper valves, and a steam pump, to pump out the bayou during high water. Even after the recommendation of the citizens commission, and its acceptance by the Legislative Council, so great was the force of general prejudice against its adoption, that much time was lost, and construction delayed until the 21st of January, 1880, when work was actually begun.

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* The Sanitary Drainage of Houses and Towns, by George E. Waring, Jr., 1878, pp. 149, 150.

† Atlantic Monthly, July, 1879, p. 61.

The work was done under the immediate direction of Mr. E. C. Metcalf, engineer in charge, Mr. Geo. E. Waring, Jr., being consulting engineer. The writer arrived at Memphis February 20, 1880, and after a few weeks spent in locating, assumed charge of construction of a section as assistant engineer.

The main sewers were located along the bayou, and ran in a general direction parallel therewith. For about four thousand feet from the outlet, one main sewer was built of brick, of twenty inches diameter, to the junction of the two main pipe sewers that ran on opposite sides of the bayou, that on the westerly side being fifteen, and the one on the easterly side twelve inches in diameter; these decreased in size to ten and then to eight inches at the upper end.

The lateral sewers were of six-inch pipe, except in a few cases, where an increased size was required, by reason of their greater length, the size being regulated by allowing a carrying capacity of about two hundred and eighty gallons per day for each city lot of twenty-five feet front, the sewers to run from two-thirds to three-quarters full.

In connection with the sewerage, the subsoil drainage received its share of attention. This was rendered necessary at Memphis by reason of its clayey formation, which prevented the infiltration of water falling upon its surface, so that subsoil water was often found in the most improbable places a few feet below the surface, and was a source of constant annoyance and inconvenience in the prosecution of the work. To provide for this subsoil drainage, ordinary agricultural drain tile, with open joints, were laid in the trenches with the sewers, and it not infrequently happened that it became necessary to lay these tile in advance of the sewers, and on a lower grade, as will be more fully explained hereafter.

The main sewers running along the bayou were located in such a manner as would best conform to the natural topography, and were carried around obstacles on curved lines whenever practicable, and thus kept at an elevation that usually avoided deep cuttings, or the building of the sewers on embankment, and as the main sewers were necessarily laid across private property, generally crossing the main streets at an angle approximating a right angle, it sometimes became necessary to carry the sewers underneath dwellings and other buildings. In low ground, when the flow line came above the natural surface, and in some other places when suitable foundations could not be otherwise secured, a viaduct was

built of small brick arches, the supporting piers being carried down to a sufficient depth to insure a stable foundation ; on this viaduct the pipes were laid, and enveloped in a ring of brick work, composed mainly of bats and broken brick obtained from a ruined building in the vicinity of the work, this was then given a coating of earth to make it secure against frost.

Great care was necessary in maintaining a true grade while laying the pipes. On account of the very small natural inclination of the bayou but very slight grades were attainable; for nearly half the length of the west side main the grade is one foot in six hundred, above that it is one foot in five hundred, and still further up one in three hundred. In order to lay the sewers carefully to this grade, stakes were set in the bottom of the trenches at stations every 12½ feet, and driven to the grade of the flow line, the pipe-layer was furnished with a straight-edge of sufficient length to reach from stake to stake, this straight-edge was just so much wider at the lower end as would represent the fall for its length, and was used by placing the narrow end in the pipe it was desired to test, and the other end on the nearest stake below the pipe, then a spirit level was placed on the straight-edge, and if not found to be level, the pipe was raised or lowered until it became so.

In some cases, as at street crossings, where the sewer came so near the surface as to endanger the crushing in of the vitrified pipe sewer at times when the ground is very soft, a few lengths of iron pipe were used.

Iron pipe will also be used for the low water outlet, and for the east side main at the bayou crossing, where the pipe is carried over on a bridge.

There are two outlets, one for high and the other for low water, and the sewerage can be turned into either at pleasure, by means of a swinging section, working in a brick chamber.

In a system of sewers like the one here described, success depends upon keeping the pipes clear and free from deposits of every kind. To do this required the greatest care during construction, consequently a departure from the ordinary methods was adopted, and the pipes were laid from their beginning toward their outlet, the joints being cemented as the work progressed ; there was thus no chance for mud and water to enter ; besides this, to avoid all occasion for deposits, great pains were taken in laying the sewers to secure concentricity and smoothness of joints. For this object an adjuster was made, which by means of three

india rubber bearings lapping the joint on the inside of the pipe, and pressing outward by turning a screw, held the two pipes firmly in position until they were secured by pressing a gasket of oakum in around the collar, the gasket serving the double purpose of holding the pipes in position and preventing the intrusion of cement, that might otherwise work through and form little ragged particles, offering obstruction to the flow, and giving lodgment to small, solid matters, in time causing serious deposits.

The flush tanks which make the separate system practicable, are placed at the head of each branch sewer of about six hundred feet in length. See Plate IV.

They are built beneath the surface of the ground, of brick masonry ; the walls, four inches in thickness, in the form of a vertical cylinder drawn in at the top, and terminating with a cast-iron cover, similar to a man-hole cover, the whole resting on a concrete bottom. The syphon which discharges the tank, consists of a cast-iron discharge pipe, fitted within a larger pipe of the same material, and rising within the centre of the tank. In operation, the tank is slowly filled by a small stream of water from the supply pipe, so graduated as to fill the tank about once in twenty-four hours, or as often as may be found necessary to flush the sewers. As soon as the tank is filled, and the water begins to drip over the outlet, the syphon is brought into operation, and the whole contents of the tank instantly discharged, and the water goes rushing down through the sewer, sweeping away such small deposits as may have accumulated since the last flushing.

Many difficulties were encountered during the progress of the work and delays were twice occasioned by the failure of the parties who furnished the pipes to deliver them promptly according to their agreement.

Subsoil water was troublesome at all times, and was always found on level ground, a few feet below the surface ; at the beginning of sewers it did not amount to much, but as the laying progressed the water flowed on down through the tile that was laid in the trench with the sewers, soaking the bottom of the trench and making it soft and muddy.

In such cases the subsoil drain was laid in advance of the sewers by digging a narrow trench below the grade of the sewer. Into this trench the tile were laid and covered with boards to prevent their being disturbed while laying the pipes.

At the lower end of the sewers a great deal of water was frequently

encountered and very soft bottom. Where the bottom was only moderately soft it was sometimes excavated a few inches below grade, and filled up with gravel. Where this process failed to give a firm bottom, recourse was had to piling. Saddle piles were kept constantly on hand and frequently used. They were made of boards of various length, with a semicircular piece cut out at the top of the proper size to fit the exterior of the pipe, these were driven firmly to the proper grade, the pipes laid and cemented and the trench backfilled. After the sewer was finished and the subsoil drain laid underneath the main sewer and extended to its outlet in the bayou, these wet places became speedily drained. The writer noticed especially one of the worst of these places where the pipe-layers were constantly half way up to their knees in mud and water, where the pipes were built up for a considerable distance on piles. A few weeks afterward a portion of this was unearthed for examination, as it was confidently predicted while being laid that this part would settle, and the joints become cracked. An investigation, however, showed it to be in good condition, and what was still more surprising was to find the trench quite dry and the filling firm and hard, notwithstanding there had been rains shortly before the examination. The outlet of the tile drain showed a small stream running continuously.

The sewers were laid on an average about six and one-half feet below the surface; as but few buildings had cellars, this depth was amply sufficient.

The tile subsoil drain was laid beside the sewer in the same trench, the joints were covered with paper to prevent the loose filling from stopping the joint, they were from one and one-quarter to three inches diameter, and were provided with an outlet in the bayou.

The work was carried on until August, but comparatively little was done after the middle of June. When the writer left (June 10) about twenty miles of sewers had been laid, and so much as had been completed was in successful operation, and the practicability of the system fully demonstrated.

The advantage of this system over the ordinary system of large sewers is two fold. It is cleaner and cheaper, cleaner because the pipes are kept constantly flushed and thoroughly ventilated; cheaper, because there is a vast difference between the cost of a large brick sewer with its manholes and receiving basins, and a small pipe sewer with its simple fresh air inlets. The difference is very apparent when it is considered that the

FIELD'S AUTOMATIC FLUSH TANK.

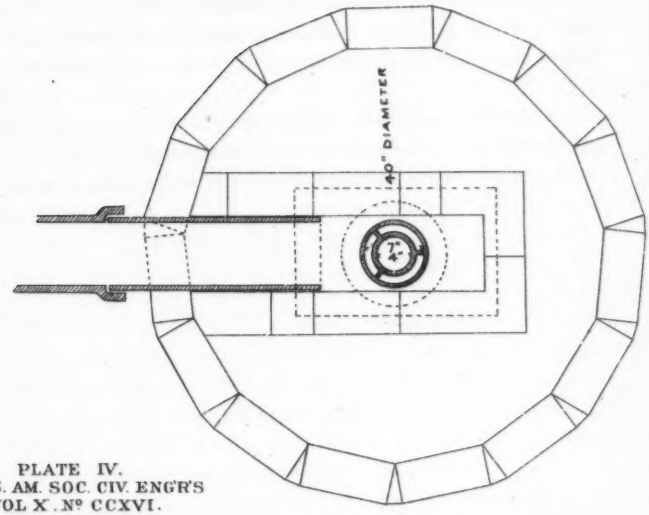

PLATE IV.
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ODELL ON MEMPHIS
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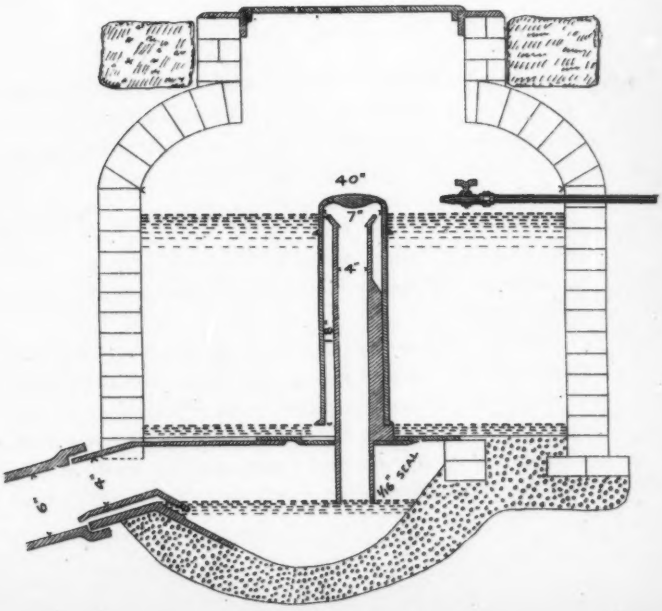

total cost of twenty miles of sewers in Memphis, for labor, materials, engineering, superintending and incidentals, including the two main sewers was about one hundred and thirty-seven thousand dollars ($137 000).

With the results already achieved by this small pipe system of sewerage, it seems safe to predict that a new era has been inaugurated, and that the coming years will witness great modifications in the prevailing methods of sewerage.

Discussion of the Paper.

Edward S. Philbrick.—I have listened to the paper that has been read with considerable interest, for it presents a subject that has not been discussed in our Society before. I am not prepared to criticise the introduction of the separate sewer system in Memphis, because I am not sufficiently acquainted with that city, but I would express my opinion as to the general applicability of this system. The gentlemen who have been instrumental in introducing that system in this country, especially Col. Waring, are all very sanguine of its being very generally applicable for sewering our large cities. There seem to me to be certain prescribed limits, depending on two or three points. First, the disposition of the surface rainfall. However proper it may have been to ignore the surface water in Memphis, there are certain of our modern cities where it cannot be ignored, and cities even smaller than New York, especially in our northern climates, as Albany and Boston, and which have paved streets impervious to water at all times. There are times when bodies of snow and ice are suddenly thawing in the spring, when without an adequate provision for taking surplus rainfall from the ground, our streets would hardly be passable; so it seems to me we cannot ignore in our climate, provision for taking off this water by underground conduits. Now, supposing such a system must be provided, the great argument in favor of a separate one for the sewage, viz., its cheapness, would depend largely upon local circumstances which would differ. I have no doubt there would be places where the duplicate system, one for rainfall and one for sewage could be constructed more cheaply than the combined system. That is to say, in cities where the rainfall can be readily got rid of to some proper place by short lines. But on the other hand, where the lines for the conduits for the rainfall are necessarily long, these conduits would require a large section corresponding to the large volume of flow which would accumulate in such length, and the cost of the duplicate system would be greater than that of a combined one. There is another objection to the separate system which may not have existed at Memphis, which would have to be taken into account in many towns where the rainfall would have to be discharged into a smaller stream than the Mississippi. In all our large towns, particularly in the

summer, and also on the thawing of a winter's supply of ice in northern cities, the waters that run in our gutters, and which we wish to get rid of, are as filthy as our sewage. The rainfall in the streets of New York at certain times would be quite as objectionable, if turned into a small stream, as the sewage of houses. If either is led into a small stream, the result would be its contamination and a mass of *debris* in the channel, which would not be endurable ; so that a separate system of pipes for sewage alone would not relieve us. This pollution of streams has caused a great deal of trouble in England. We can hardly appreciate the trouble which has arisen there. In many districts, though you probably all have heard of it, in the last few years it has become an evil of so great a magnitude that it is considered one of the most difficult questions to be encountered, what to do with the sewage of towns.

There are, unquestionably, many towns where a separate collection of the sewage would be a great advantage. Such is the case wherever the sewage must be pumped or treated artificially, or used for irrigation of land. In these cases, the introduction of rain water becomes a great encumbrance. Its maximum volume is large, and attained only on rare occasions, therefore, not only must the conduits be large, but also all the plant for handling and treating the sewage, a part of which plant will lie idle and useless for most of the time. Moreover, if the sewage is used for irrigation, the rain water is most abundant at times when it is not needed for the growth of the crops; in fact, it becomes an injury to them, while in times of drought the sewage may be barely sufficient for their wants. So the sewage farmer gets most sewage when he needs the least and gets least when he needs the most. It is not surprising, then, that all men who have been, or are now, interested in sewage farming should be zealous advocates of a separate system of pipes for collecting the sewage by itself, without rain water.

Moreover, in many other places a separate system of sewage can be carried out with success, where population is so sparse that the streets will not be very filthy at any time, and in such towns as cannot afford to provide extensive conduits for rainfall, and where the character of the soil may be so porous as not to require the construction of such conduits. Reverting to Memphis, I am aware that the circumstances are represented to be such in that city that the amount of rainfall is got rid of readily without encumbrance, but I don't think this is a fair test, if applied to many northern cities. There are also many matters of detail

in the Memphis sewers which I would question. Among others, the absence of man-holes. Now, in constructing a separate system for sewage alone, the cost of man-holes would be a very large item, the pipes being small, and their absence in Memphis is, therefore, a very considerable item when compared with the cost of the sewers alone. It seems to be questionable whether any permanent success can be had by building a large number of sewers in such a condition. You all know we cannot prevent substances going into them that should not go there—garbage, rubbish, boots and shoes, etc. Those who are familiar with the care of sewers in our old cities, find many such things are to be taken out. In short, I think the system of sewers, without man-holes, cannot be operated smoothly for any length of time.

J. J. R. Croes.—The paper under discussion explains very clearly the fact that the flush tank is the one feature in the sewers constructed at Memphis, which renders the system adopted practicable. In the official statement of the National Board of Health on the Memphis sewerage, it is said, "this flush tank is one of the essential features of the "combination; indeed, without it, the use of any sewers not receiving "storm water would be extremely unsafe."

The successful working of this ingenious appliance depends upon two conditions; a constant supply of a small stream of water, and the keeping of the two syphons in clean condition. It seems to me to be possible, that in the difficulty of maintaining these conditions may lie a serious obstacle to the permanent success of the system which is entirely dependent upon them. There is so much sediment in the water supplied to most of the towns in the West and South, and this sediment is deposited so quickly in still water, that it does not seem unlikely that frequent obstructions might occur in the tanks into which the water flows at the rate of only a gallon in twelve minutes, to be emptied only once in twenty-four hours. The stoppage of the lower syphon, in the exit pipe destroys the action of the upper annular syphon, and the water dribbles through instead of rushing out in great volume. The obstruction of a portion of the annular opening of the main syphon has practically the same effect, or if it does work, it empties the tank so slowly as not to produce the desired effect. It is an open question, which the short experience had at Memphis has not yet decided, whether a delicate mechanical contrivance like this can be depended upon to work automatically for a long time, and whether the cost of inspection and maintenance

of a great number of them will be less than the interest on a larger investment which costs less to maintain. Besides, any failure or deficiency in the water supply such as is likely to occur in all of our towns in seasons of drought would be apt to affect the system injuriously.

The Memphis sewers were constructed, as is evident from Mr. Odell's paper, with great care, under the immediate supervision of intelligent engineers. The system was on trial, and the work was executed with the exactness of a sample work. Its successful working during the six months of its existence has made it a good advertisement of the system, not intending the word advertisement in any offensive sense. As a result of this, it is understood that a company has been formed to apply the same system to any town at moderate rates. I cannot think that this mode of sewering towns by contract for a gross sum, untrammeled by interference with details on the part of the engineers acting for the other party to the contract, is conducive to good workmanship or satisfactory results. "Lump contracts" are seldom properly executed throughout, and the tendency to slight or omit some important feature is too great to render such a procedure generally advisable.

Some of the details of the Memphis work, as reported, must be considered as of doubtful value. Mr. Philbrick has alluded to the absence of any provision for examining the pipes and removing possible obstructions without digging up the street and breaking the sewer. Whether the saving of first cost in this manner will prove an economy is yet to be demonstrated, and experience alone will show. It is one of these questions which cannot be reasoned out, and the experience of Memphis will be of great value in its solution.

The method of adjusting the pipes so as to secure concentricity is of doubtful value. A channel which is smooth on the bottom is better adapted to the flow of sewage than one in which the irregularity at the joints is distributed around the circumference.

The gaugings of sewers made by Mr. Waring by order of the National Board of Health, and published in the supplement to their "Bulletin" for September, 1880, show as nearly as can be judged, that the ordinary maximum flow of sewage alone, from a population of 1 000, in moderate sized towns, with plentiful water supply, would occupy an area of about from 10 to 12 square inches, or less than one-half of a six-inch pipe. The main flow being below the centre of the circle, it is much more import-

ant that the bottom should be true to line at the joints, than that the axis of the cylinders should be a straight line.

The emptying of the flush tanks can fill the pipe for only a short distance from the tank, and, consequently, the useful effect of the flushing is actually diminished by the device employed to ensure straightness of axis.

The supporting of the pipes in soft places on the ends of boards does not appear to me a good plan for durability, though it unquestionably facilitates construction very much. The plan adopted of laying the pipes down hill was a good one, but is not entitled to the claim of novelty which has been made for it. It was adopted in some of the sewers laid in the Twenty-third Ward of New York by the Park Department, three years ago. In the specifications of the contract for building a sewer in Third avenue, One Hundred and Thirty-fourth and One Hundred and Thirty-fifth streets, prepared by Mr. E. B. Van Winkle, Member A. S. C. E., which contract was let on August 21, 1878, it was provided, that "all pipe sewers shall be commenced at their highest points, and laid down towards their lowest points, unless specially advised to the contrary." It is very probable that it has been done elsewhere also.

The gaugings of sewers made by Mr. Waring, to which I have alluded, are of great interest, and ought to be republished in more complete and accessible form. If the National Board of Health would now direct gaugings to be made of the maximum flow in storms from sewers, much important information might be obtained as to the proper size for "combined" sewers. Storm-water conduits have to be built in most towns, and the determination of their minimum allowable size appears to me as important from an economical and sanitary point of view, as that of the size of "separate" sewers.

GEORGE W. DRESSER:—This system involves the construction of one set of sewers to take the house drainage, another for the subsoil drainage, and still another for surface water. Now one good system, I think, is better than three, and from what I have had to do with sewers, I would rather have one good one than three. The sewers built in the town of Lennox, Mass., several years ago, give satisfaction to every one there as far as I know, but that is in a country town, sparsely built, with several acres of ground to each house, on each side of a very few streets. But that is different from putting small pipe sewers through New York. With a house on every 25 feet, we have very nearly five hundred houses

from Fifth avenue to the river on a street like Twenty-third street; and nearly all of those houses have a great pipe delivering its sewerage, surface and roof water into the sewer. There is no chance for infiltration, and the greatest rainfall must be provided for.

Another point claimed with reference to these sewers, as proposed, is their certainty of always being clean. I don't think time enough has elapsed to settle that point. A gentleman, somewhat interested in the matter of the drainage and sewerage of houses, showed me an experiment that he instituted last summer. Coming through his room was an ordinary waste pipe, a soil pipe 4 or 6 inches in diameter, made of cast iron; it came from the floor above directly through this room, carrying the waste water of the apartment above to the sewer. He made an opening into this pipe by which he could observe the effect of the use of the pipe upon the pipe itself. It was arranged with a down ventilation, and after that pipe had been up, I think two years, there was a coating of at least half an inch in thickness adhering to its interior, and this was a vertical pipe which was flushed every time it was used. That lead me to conclude that if a crockery-ware pipe of the same size, was laid horizontally, it would be more likely to clog than a vertical one. If that coating formed on a vertical pipe, why should it not form on a horizontal pipe? I should think the experiment at Memphis should have more time before its ultimate success can be determined.

With reference to the man-holes, the only alternative that is left is in case of obstruction to dig up the sewer, clear it and replace the same. Now every one knows how difficult it is to replace work that is once broken up, to dig down and get the pipe back in as perfect a condition as it was before it was taken up, is almost impossible practically. With reference to rubbish, it is very remarkable what rubbish does get into an ordinary house pipe. In a case in my own house, I found in going to the water closet one morning, in pulling the plug, that the thing didn't work; the water did not run off. I sent for a man to see what was the matter, and there he found a large sized scrubbing brush, carefully deposited in the trap. It had easily slipped from the house maid's scrubbing pail, but the trap could not pass it along. Had the trap been large enough to allow it to float through, it would have formed a serious obstruction in a 6-inch crockery pipe.

ROBERT CARTWRIGHT:—I find in the kitchen waste water a much more formidable agent in closing house drains than the discharge

from the water closet. My attention has been directed for some years to the closing of drains by the fatty deposit introduced with the dish water and kitchen slops, and my experience has been, that it is due to the lowering of the temperature of such waste as it enters the line of sewer, and congealing the fatty matters upon the interior of the drain. Daily additions, more or less, render it only a question of time when the largest drain will be completely stopped by it. This it seems to me will be a serious objection to the system as proposed by Col. Waring. His periodical flushing of the drains by means of flush tanks, will not remove that greasy deposit, for it sticks like a brother to the pipe, but rather tend to reduce the temperature of the drain and congeal the fat all the more rapidly.

I have been recently obliged to take up a drain in my cellar, on account of its being closed. I found at the point where my kitchen sink connects by means of a 2-inch lead pipe with U trap to the 6-inch cement sewer, that the two lengths nearest the inlet were completely filled with a compact mass of the consistency of tallow. Beyond these the drain was only partially filled to a point some fifteen feet away, beyond that all was clear. I have, about 25 feet away, a 4-inch cast iron pipe carrying into the drain the waste from a sewing machine hydraulic motor and two water closets, but there was not the least deposit there, though the closets have been in use for my family of thirteen for some six years. About two years ago I had to take up the drain at the same place, and found the same state of facts existing.

I experimented with potash, dissolved in hot water, and found that it would dissolve it, if in contact long enough, but the effect was to cut a small channel to the bottom of it, thus only partially clearing the drain, leaving but a small opening, to be closed again very soon. Besides that the expense was too great for potash, even for the small opening it made.

Obviously, it would be of no use to turn in steam or hot water, as that would only shift it to some more remote point, to the street sewer possibly, to be there congealed and cause a stoppage, where it would require greater outlay to remedy.

Inasmuch as oleomargarine was first obtained from fatty matter collected on balls of horse hair immersed at the outlets of the sewers of Paris into the Seine, I think that unless a means can be devised to dissolve, and keep it in solution, with the sewer water as a vehicle to carry it off, we shall be obliged to remove it mechanically as heretofore, and

then there is a fortune awaiting some individual who will collect this material for the market.

In my own drain my rain conductors connect with my sewer beyond the point where kitchen connection is made, as also my barn and work-shop waste. This gives me the benefit from washing carriages, and a Backus motor discharge constantly running its water to flush the drain, but it stops at the kitchen connection, notwithstanding all the water turned in. This is certainly tangible evidence that cold water won't prevent stoppages caused by kitchen slops.

SAMUEL L. SMEDLEY :—Notwithstanding the greatest care in flushing, grease and other adhesive substances will accummulate on the sides of the drains, and this is liable to increase, as has been here stated, until the pipes become closed with fatty matter, which, when cold, becomes stiff and hard.

In Europe, where these small pipes are used extensively, the man holes are placed very close together, so that the obstructions can be removed manually, by operating between two manholes.

Mr. Fowler, of New Haven, informs me that he introduces wooden balls, somewhat less than the size of the pipe. Several of them are joined together with cords, and the flushing under a head causes the water to spurt around the balls with great effect, thus tearing away and removing the obstruction.

Solutions of potash are sometimes used, but this is not generally satisfactory, because only a narrow opening is cut, leaving the bulk undisturbed.

Although the flushing tanks in Memphis may be generally effective, I think the pipes will frequently become choked. I do not see how these obstructions can be got at and removed conveniently with such a limited number of man-holes as Mr. Waring has put in.

I agree with what has been said here on the necessity of providing a full system of sewers for storm water in large cities. The natural drainage areas covered with houses, are so enormous in many places, that the surface accumulations from an ordinary rainfall would make the crossings of streets impassible to pedestrians. Many such areas exceed 1 000 acres. The Cohocksink basin in Philadelphia, contains 2 500 acres, and the summit is 25 000 feet from its outlet at the river, with paved streets nearly the whole distance. An eighth of an inch rainfall in one hour, would fill the lower streets a foot deep from curb to curb. The public convenience

demands that storm water should be removed from the surface of the streets, as speedily as possible, and to do this sewers of great capacity have to be built, capable of carrying from ten to twenty times the quantity of sewage proper. These large sewers are, of course, enormously expensive; but they have to be built to accommodate the public. Where is there a large community which at this day would bear the additional expense of a complete separate system for house drainage? The fact is, we need to have all the available daily flow of water introduced into these sewers, so as to aid in cleaning them when there is no rain to carry off the sediment. The separate system may be adopted very satisfactorily and economically in small towns, or in narrow cities spread along a river front, when the rain water will quickly flow away without too much accumulation; but large cities generally will require large sewers to get rid of storm water, the cost of which is burthensome enough without the expense of an additional system. Some engineers thoughtlessly say "build storm water overflows for relief," which is an absurd proposition where the main sewers do not run parallel to a river or stream, but are built, as they generally are, nearly at right angles to a river, in the direction of the natural slopes of the territory.

William E. Worthen.—In Brooklyn, where many large areas have been graded in the interest of the land owners, from considerations of economy of excavation and fills, and large pockets or basins have been made thereby, the rain water cannot be discharged by the street gutters alone, and even with the most approved system of street grades this city, from its position, its large extent, and the great length of water courses necessary for the removal of rainfall, would still, for this purpose, require deep sewers. Such sewers have been constructed there, and as Sanitary Engineer of the Metropolitan Board of Health, I have examined many and found no reasons why they should not serve both purposes—removal of rainfall and house sewage.

In cities there are three purposes to be served by sewers, or their equivalents: the drainage of the ground below the level of the cellars, the removal of rainfall and the removal of house sewage. The first is, in a measure, served by the construction of box drains along the lines of small water courses, which, in the early occupancy of a town, are often necessary to prevent the grading of the town lots from obstructing the flow and forming stagnant pools. But when the box drains are covered by deep fills, but little water gets into them. When the streets are

graded and lots filled, provision must be made for removal of the rain, and if the streets are not paved it is the simplest way to make use of gutters and open drains; but when the streets are paved and houses built, so long as the underground drainage is served by the old box drains, and the rainfall can be taken off by the street gutters, a system of pipe drains will serve very well for the removal of house sewage. But as by the regulations of Boards of Health in the neighborhood, back yards are to be connected with sewers, and as no gutters from leaders are allowed across sidewalks on account of the winter ice, at least two-thirds of the rainfall is to be taken off by sewers. If, therefore, a single system of sewers can be made to serve for the removal of ground water, rainfall and house sewage, it would seem to be the simplest and best; but the function of street gutters should not be overlooked, and provision should be made, by so grading the streets, that the rainfall thereon should, as much as possible, be taken off by the gutters—to keep the sewers of as small dimensions as possible, and provide against very heavy rains which occur at intervals of a few years. No system of sewers can be arranged without full consideration of the position of the city to be sewered, its geographical configuration, its extent, the needs and habits of its citizens, and its financial ability.

J. J. R. Croes.—The precise effect of the flushing tanks has not been accurately described in any account of the Memphis works that I have seen. A number of letters from itinerant committee men who have been taken to a hole near a tank and allowed to look in at the proper time and see a rush of water, have been published in the newspapers all over the land, but no engineer has, so far as I know, given any account of the distance from the tank that the high velocity of the flushing water is maintained. From each tank, once a day, 15 cubic feet of water are discharged in 35 to 40 seconds. The initial velocity of discharge through a six inch pipe is therefore two feet per second. This velocity is, of course, soon lost, and it would be interesting to have some observations on the fluctuations of velocity and depth of water in the pipes at points some distance from the tank connections. In operating the system it would be useful to know also how the discharge of the several tanks should be arranged as to time, so as to produce the best effect. These details are of so much value to those who will have to pass judgment on the system as applicable to different places, that it is hoped that some engineer will examine into them and report the facts.

EDWARD S. PHILBRICK.—I believe the flushing, as practiced at Memphis, serves very well for the pipes in the immediate vicinity where it is applied. The velocity of the stream—the flushing stream—is never more than that due to the fall, and this extra fall is soon distributed over a considerable length, and therefore looses its efficiency in a few rods.

The durability of stoneware drain pipe has been questioned. I have recently been taking up some old drain pipes that I had laid from a house 25 years ago—some of the first pipe made in this country—and I was gratified to find it perfectly clean, and absolutely in the same condition as the day when laid. They were 5-inch pipes. At the same time iron pipes would not remain clean, for they would be subject to some corrosion, which serve as a nucleus on which slime collects. Iron pipe should always be used inside of the building because its joints are more secure, but I think it is a fact beyond dispute that vitrified and glazed earthenware has the property of keeping clean from everything but kitchen grease. The grease that comes in with dish-water is of such a nature that I know of no means of cleaning it out except by mechanical processes. Flushing from the tanks will not remove it after it has once collected. I find that in all drain pipes having a rapid fall, grease does not collect. This accumulation of grease in pipes is a great nuisance, and wherever it has been in my power I have endeavored to intercept it by tanks, but some of it will pass through if these tanks are neglected, and the only sure way is to have a rapid fall for it.

J. J. R. CROES.—Suppose the flushing occurs only once in 24 hours, will that suffice to prevent the accumulation of grease?

EDWARD S. PHILBRICK.—I cannot say. This collection is continuous and comes in with dish-water. In this very drain, above referred to, after laying 25 years, which I had occasion to take up, I found it filled solid with grease for about six feet in length, near the house, from neglect of the tenant, who omitted to clean the grease from the tank provided to intercept it, and it would have passed very well for oleomargarine. The first thing we knew of it was the backing up and overflowing of the sewage obstructed by the accumulation of grease. There was no other way or vent but to back up and go into the rain-water cistern through its overflow, which was injudiciously connected with the drain.

ROBERT CARTWRIGHT.—The countries in Europe might live on what we waste through our sewers. We actually waste more than would keep

a nation alive. The separate system may work in England for a time, the same way as the Tay Bridge stood for a while, but it came to a short end.

ASHBEL WELCH.—From the descriptions of the topography of Memphis it appears that the distance that the storm-water had to go is in no case more than three or four blocks to an outlet, and that there are no pockets like those mentioned as existing in Brooklyn.

JOHN BOGART.—The criticisms we have heard to-day upon the plan of sewerage which so far has been in successful operation at Memphis, have been severe, but this criticism will be advantageous in developing what good there may be in it, if any exists. I do not understand that the system described was adopted for Memphis without deliberation. In fact, I understand that it was adopted upon the recommendation of engineers who had given the matter very particular consideration, and who decided to recommend this system after a careful comparison of the plan proposed under it, with other plans for the sewerage of that city drawn up with provisions for taking the storm water. Of course the element of expense was serious, and I believe that it was deemed impossible to raise in that city enough money at that time to pay for the proposed storm-water sewerage. If this system that has been adopted does not work at all as has been prophesied, or only works for a short time, the fact that it is cheap will not make it economical; but if it does work for a few years, and even if after that time it does require additions, as for instance, man-holes, the beneficial results to the health of that city will doubtless be enormous. The fact is that a system of sewerage has been put in at Memphis which Memphis was able to pay for, and I understand that without some system of sewerage there was a probability that the city would have to be abandoned as a place of residence.

There are other cities where this or a similar system of sewerage may be applicable, for a different reason; for instance, in a large portion of the City of Baltimore it is considered by the citizens to be desirable that the storm water should run through the streets, and it is believed that the streets are kept much more clean than they would be without this storm water. The adoption of a system which would take the storm water from the surface of the streets would perhaps not be favorably looked upon, and consequently if

this system which we are now discussing proves successful, it will give such a city an economical method for disposing of its sewage.

The difficulty of disposing of storm water is much less in the southern cities than in those further north where frost is taken into account. It seems to me that, on the whole. we may look upon the experiment at Memphis as an advance step in the treatment of this important department of the provisions for life in cities, and that should it prove the decided success which is believed in and hoped for by many, we may congratulate ourselves that this has been first accomplished in the United States.

SAMUEL L. SMEDLEY.—The City of Baltimore does not have the difficulty that has just been explained to us with regard to Brooklyn. Nearly all our large cities are situated just as Brooklyn is—that is, the streets are laid out in straight lines and parallelograms over territory without regard to its topography. The consequence is, there must be basins, because there is no large city that is not full of basins, because people do not follow the lines of topography in laying out their towns.

GEORGE W. DRESSER.—Except Boston.

SAMUEL L. SMEDLEY.—I don't think the tendency of this discussion has been to condemn the system for Memphis, under the circumstances. It was represented here, however, that there were no man-holes put in the system. If that is the case, it strikes me that is a great defect.

ROBERT CARTWRIGHT.—The town of Stamford is now adopting that system. Stamford is nicely situated for surface drainage. They contemplate man-holes in connection with the system. The same system has been adopted for a number of years in Birmingham, England.

J. J. R. CROES.—I do not understand that the entire separation of sewage and storm water which Mr. Waring advocates, and which has been carried out at Memphis, and recommended for Newport, Stamford and other places, has been practiced anywhere in England. In what is there called the "separate system," the rain water from roofs and back yards is allowed to enter the sewer, but the street wash is excluded.

The Memphis work is attracting as much attention there as it does in this country, and the results of a continued trial of it are looked for with great interest.

The omission of man-holes does not seem to be a part of the "system." In this case it was an expedient adopted to reduce the first cost to the lowest possible point, in order to enable anything at all to be done.

GEORGE W. DRESSER.—I wish to state, as a matter of information to the members of this Society, that we must not flatter ourselves that it is not proposed to put this system in everywhere. Perhaps we may admit that it will do in a small town, in all probability, however, as I have been informed, this system "is bound to be adopted in Paris, London, and many other large cities." I think it is a very happy thing that the matter has been brought up here for discussion. If we have got to take hold of it, we must make it work. We must not sit down and ignore it. The proposition is, to have separate sewers adopted everywhere, and if we have to build them, it is a good idea to talk these things over beforehand and be prepared to do the work well.

GEORGE E. WARING, JR.—I have been much interested by Mr. Odell's paper, and by the discussion to which it has given occasion among engineers, with whose study and practice the system described is so much at variance. The subject has, naturally, been approached mainly from the side of constructive engineering. The traditions of the profession have been formulated with the prime view of getting rid of water. The prime object in the new method is to get rid of filth, or of what would become filth if not removed before decomposition, and of resultant "sewer gas."

Mr. Odell's paper is substantially correct. The commission, however, did not seek my council. I was one of its original members, and my suggestions were unanimously accepted after an exhaustive argument in favor of the plan proposed by Messrs. Hermany and Chesbrough, the former being present and taking an active part in the discussions.

In what I have to say I shall consider the paper, and the comments it has called forth, as a whole, and shall meet the criticisms advanced as completely as I may.

I have not ignored the storm-water question. I fully recognize its importance, and maintain only that it should be treated as a separate subject, chiefly as a purely physical subject, and that the manner of treating it should be such as to call for the least outlay; such as to secure cleansing action at the surface so far as practicable; and especially

such as not to interfere with the more vitally important work of removing the wastes of human life.

The sanitary consideration should be, *facile princeps*, the controlling consideration. To this opinion the civilized world is, I think, fast coming.

There are special cases where the conformation of the surface, as in Brooklyn and in St. Louis, but by no means generally even in large cities, calls for special means for the underground removal of storm-water. There are many other cases where, from mere accumulation, the flow becomes too great to be allowed to remain above ground. But however frequent, these cases are far from being universal. Where they exist very shallow sewers would be as effective as deep ones, and no sewers are needed (for the removal of storm-water), save to relieve the basins or to remove too great accumulated flow. In favor of keeping rain-water on the surface as long as possible, there are many arguments, not the least being that we thereby retard its discharge and may restrict the mains to sizes which would be quite inadequate if the whole rain fall were delivered by conduits of great velocity.

To say that "this system requires the construction of one set of sewers to take the house drainage, another for the subsoil drainage, and still another for surface water" is not strictly accurate. It requires one complete set of sewers for house drainage, draining tiles in the springy parts of the soil (laid in the sewer trenches), and occasional sub-surface channels for the removal of accumulations of storm-water.

To say that "one good system is better than three" is specious, inasmuch as the most important function of a sewer—the complete and quick removal of matters which may become injurious if retained—is hindered by charging it with the removal of storm-water. No sewer can be entirely "good" for both offices.

Neither is the filth of the streets an argument in favor of storm water sewers; it is rather an argument in favor of proper street cleaning—such as that of Paris and of Washington. Whatever is done with street dirt it surely should not go into sewers. In making this statement I am, of course actuated, above all, by the sanitary consideration—but not heedless of other bearings of the question. These other bearings were unfortunately, an embarrassment in Memphis, for—contrary to the accepted notion—there are few towns where storm water does so much harm as it does there. I simply did not allow storm water to interfere

with the proper removal of household and other waste, but recommended suitable surface or shallow channels.

It is suggested that the gauging of sewer flow be extended to cover the flow of storm water. This would hardly be useful, for the reason that the conditions controlling such flow are not constant; too much variation results from an extension of the receiving branches, from the greatly changing volume of rain fall, and from the changing character of surface, as building and paving increase. We know more now on this subject, from actual experience in London and other large towns than any gauging could teach us.

The chief criticisms of the Memphis system which have been brought out in this discussion, are as follows:

1. Man-holes should not have been omitted.
2. The concentric laying of pipes is a mistake.
3. The board piles used for supporting the pipes in soft ground will not be durable.
4. The sewers will become foul from the adhesion of grease and other matters.
5. The flush tanks, "delicate mechanical contrivances," depend on a constant water supply; they will fail from an obstruction of the siphons; they will become choked with sediment; and as the initial velocity of their discharge is only 2 feet per second, their effect will be lost within a few rods of the tank. Also, the tanks must be nicely timed to supplement each other's action.
6. The falling of the Tay bridge indicates that though working well for a time, this system will come to a "short end."

Permit me to consider these objections in their order:

1st. The Memphis system is an entirely new system. None of the so called "separate" sewers in England resembles it except in the exclusion of street water. They admit roof water and yard water. They have no provision for periodical automatic flushing; none for the restriction of the size of the house connection, to prevent the passage of bulky objects; none for complete and systematic ventilation; and none for the exclusion of joint mortar which is a frequent source of obstruction. Then again, the pipes used in the English examples referred to are generally much larger than those used in Memphis. Therefore, the supposed need for man-holes is not necessarily applicable here. Perhaps, too, it would be instructive to know to what extent the man-

holes are used in England or here, either for inspection or for cleansing.

The sewers of Lenox, constructed in 1876 (all 6-inch) have a few man-holes. The only use ever made of these is for a very infrequent hand-flushing. There are no flush-tanks there, but roof water is admitted to the heads of the sewers from adjacent large buildings. The Lenox sewers are free and clean.

The sewers of Cumberland Mills, Maine (all 6-inch), have no man-holes, and they have flush tanks. They have been in operation more than two years without stoppage or fouling. In Memphis, there are over 20 miles of sewers, and their use began in April last. In that time there have been, in all, eight stoppages; some of these from substances carelessly left in the pipes at construction; most of them on curves, where the joint at the outside of the sweep was open wide enough to catch sticks, bones, etc., and an undue proportion of them in the work of a single engineer who was ambitious to control the laying of too many lines at once. The whole cost of locating and removing obstructions, and restoring the sewer and the street has been about $125. for the whole eight. Incidentally we have learned how to avoid defects which have caused nearly all of them. Among other things, I have devised a hand-hole which will obviate the necessity for breaking the pipe, which will prevent earth from falling into the sewer during the removal of obstruc-struction, and which, while adding very little to the cost of the work, will make it easy to remove any obstruction. The opening of the street will still be necessary. The cost and annoyance of doing this on rare occasions is much more than offset by the fact that we carry all house connection branches to the line of private property during the original construction, and thus obviate the much more considerable openings, which in ordinary practice are made by plumbers whenever a house is connected. In any case the occasional openings needed to remove obstructions will be trifling as compared with openings made to reach gas and water pipes —about which no engineer complains.

Some rubbish will, of course, get into the sewers and some obstructions will occur, but scrubbing brushes will generally be retained in traps and not much will pass the 4-inch house drains which will stick in the flushed 6-inch sewers. Most of the rubbish spoken of as found in sewers gets to them through street catch-basins, and in Memphis there are no such basins.

2d. The concentric laying of pipes is, in my judgment, very important. In its absence the whole irregularity of size may, and generally does, come at the flow line. It is never very great—in 6-inch pipes—and if equally divided is of little importance; if all at the bottom, it might be objectionable. Furthermore, proper gasketing is only possible with concentric laying, and this is most necessary.

3d. The durability of the board piles is not of the slightest consequence; when the earth has become firmly settled and compacted about the pipes, their help is no longer needed, a pipe—or a brick or a chip—once imbedded in a nidus of earth, deep in the ground, must remain unmoved, and the joints of a pipe sewer so imbedded are safe for all time.

4th. The discussion of the "grease" question seems to have answered itself. The greatest distance mentioned at which grease was found was (Mr. Philbrick) 6 feet from the sink waste. Mr. Cartwright found it for two lengths of pipe (4 feet). At a distance of 15 feet the drain was clear. If householders are careless about their grease, it is their own drains, not the sewers which will suffer. The grease found in the Seine did not adhere to the walls of the sewers. It was what had been washed out of the drains in a condition to be carried forward by the flow.

I know very well, and have often examined the soil pipe to which Col. Dresser refers. The condition of its walls is the same as is found in all vertical, round waste pipes, and is familiar to all who have investigated the drainage of houses, even casually. It is asked: "If that coating formed on a vertical pipe, why should it not form on a horizontal pipe?" Simply because water falling through a vertical round pipe loses its flushing power by swirling. The moment a pipe is sufficiently inclined to cause a direct flow the flushing power is restored, and the pipe is kept clean. Such deposits are never found in horizontal pipes with sufficient flow. The sewers in Memphis are entirely clean, so far as the eye can detect.

5th. The flush-tanks are not a delicate mechanical contrivance any more than mill dams and stand pipes are—they have no moving parts of any sort—and they do not require a constant flow. When they receive no water they do not act, but whether their supply is regular or irregular, they discharge whenever they become full. Being lower than the houses they are sure to get their share, if there is any supply at all. There has been some trouble from the choking of the small subsidiary siphon,

and its use, and the need for it, have been obviated. The main siphon cannot become clogged by any water, no matter how impure. Its rushing discharge carries away all obstructions. The same cause prevents the accumulation of sediment anywhere in the water-way.

Perhaps the initial velocity would be only two feet per second, if the discharge of the tank filled the six-inch sewer full, and still required 35 seconds. It does not so fill it, and the velocity is very great. Instead of "losing its efficiency in a few rods," the flushing stream, according to observations make in Memphis, fills the sewer more than half full 900 feet from the tank. This distance must, of course, depend on the fall of the sewer. At 1:200 it is ample to wash all filth forward to a point where the natural flow is able to take care of it, and that is all that is asked of the flush tank. Each tank has only the dead end of its own sewer to flush. It is immaterial whether all go off at once or irregularly.

6th. The Tay Bridge comparison is not pertinent. Although the use of a system of sewerage such as is now under consideration has, as yet, had a practical trial of less than one year, it is known to the profession that indestructible pipes, securely laid in the ground, with a sufficient fall, and a sufficient volume of flow, will discharge sewage for all time. Even 12-inch pipes, not clogged with street dirt, keep themselves clean with a current not more than three inches deep, and the smaller the pipe the more cleansing the current of a given volume of sewage. No new principle is involved here, only a new application of principles which have long been familiar.

Mr. Croes says my gaugings show, "That the ordinary maximum flow of sewage alone, from a population of 1,000 in moderate sized towns, with plentiful water supply, would occupy about from 10 to 12 square inches, or less than one-half of a 6-inch pipe." That depends. Sectional area depends on velocity, and velocity depends on fall.

Mr. Croes speaks of a claim of novelty for the laying of the pipes from the head of the sewer downwards. Mr. Odell only spoke of this as a "departure from the ordinary methods," and it is that.

The same speaker cautions us against allowing sewerage work to be carried on "untrammeled by interference with details on the part of the engineers acting for the other party to the contract." This is not suggested in Mr. Odell's paper, nor, so far as I know, has it been proposed anywhere. The engineer of a city has the same control over the

construction of sewers in gross, that he would have in detail. If he can secure adherence to specifications in the building of a 6-foot sewer, he can do the same in the building of a -inch sewer. So, also, he has an influence in the selection of a plan, and in the determining of its details, in proportion to his ability to convince his municipal authorities of the wisdom of his views.

In closing, I beg to say that the adoption of the general principles of the Memphis sewerage and the regulation of its details—and, I trust, I shall not be accused of immodesty in saying it—has been no hap-hazard, ill-considered work. To the best of my ability, I have, during the past twenty-five years or more, studied with great care what has been said and done and written on the subject of town and agricultural drainage in this country and in Europe. I have considered, so far as my opportunities and my abilities have enabled me to do so, all conditions to be met, and all elements of the art. Drainage has been my specialty from the outset, and, I think, I may claim such confidence as is due to a man of common intelligence, who has made a careful, life-long study of a single branch of engineering.

I submit to the world, as the best works of which I am capable, this system of sewerage, now working in Memphis. That it is by any means perfect in its details, I do not pretend. That these details will not be greatly improved by the efforts of others, it would be fatuous to suppose. Had I had more money to spend in Memphis, some of them would have been more complete than they are.

At the same time, I am convinced that the main features of that system are strictly correct; that they afford the only relief yet devised for the defects of the prevailing methods of town sewerage—these methods being the outgrowth of traditions which ante-date the rudiments of sanitary knowledge; and that some of us will live to see the day when the Memphis system shall have supplanted the storm-water system as completely as the present development of the storm-water sewer has supplanted the huge irregular culverts of thirty years ago.

It is noteworthy that in this discussion the two fundamental benefits which my sewerage secures, have not received the faintest allusion; noteworthy because this is a meeting of engineers, more or less engaged in sanitary work, and, therefore, owing prime allegiance to the public health.

No word has here been uttered on the subject of filthy accumulations in catch-basins and in sewers too large to be cleansed by their natural flow, which the Memphis work avoids; nor on the subject of foul and dangerous gases resulting from the decomposition of this filth. No reference has been made to the fact that waste matters delivered into the head of the remotest sewer in Memphis, are shot into the Mississippi river within two hours time, and that the slight sliming of the walls of the pipes, delivers the resultant gases of its decomposition into an atmosphere so freely and so constantly renewed, that "sewer gas" is unknown there.

Deviations from the established methods of construction have been condemned, either directly or by implication; but no recognition has been accorded to features which sanitarians, here and abroad, have accepted as most essential merits.